LOUISVILLE METRO

TRANSFORMING DIXIE HIGHWAY

TIGER DISCRETIONARY GRANTS PROGRAM

BENEFIT COST ANALYSIS SUPPLEMENTARY DOCUMENTATION

JUNE 5, 2015

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1. Executive Summary

The Louisville/Jefferson County Metro Government, and its partners, the Kentucky Transportation Cabinet (KYTC), Transit Authority of River City (TARC), and Metropolitan Sewer District (MSD), is seeking $16.9 million in TIGER FY 2015 funds for the Transforming Dixie Highway project. These funds will leverage significant funds committed by the Kentucky State Legislature through the Kentucky State Road Fund and funds allocated by Louisville Metro Government totaling $12 million in local and state matching funds committed for these projects. The total cost for entire project is $28.9 million, of which 58.5 percent would be TIGER-funded, with the remaining 41.5 percent in local matching funds. The project is expected to reduce accidents, improve travel times and transit usage, and make the corridor more attractive to pedestrians and commerce.

The project's contribution to the state of good repair outcome stems from its impact on lifecycle pavement maintenance costs that results from a reduction in vehicle miles traveled (VMT) and by the residual value of the improvements at the end of the analysis horizon. The project will foster the economic competitiveness of the region by improving the mobility of people within the study area, in particular by reducing out-of-pocket transportation costs for people who divert from auto to buses, and by reducing travel time for car drivers and for existing transit riders. Moreover, diverting trips from auto to buses will reduce greenhouse gas and air pollutant emissions and contribute to the environmental sustainability. In addition, the project will significantly reduce crashes and injuries along the corridor.

A table summarizing the changes expected from the project (and the associated benefits) is provided below.

Table ES-1: Summary of Infrastructure Improvements and Associated Benefits

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternatives	Type of Impacts	Population Affected by Impacts	Benefits	Summary of Results Discounted 7%*	Page #
Corridor Traffic Injuries / Fatalities ▪ Outdated signal system and high traffic volumes result in increased congestion and increased collisions ▪ Limited sidewalk areas ▪ Limited pedestrian crossing and pedestrian signals ▪ Excessive speed in areas where road is wider and from inconsistent typical section	Access management, including adding sidewalks and improving crossings ▪ Design for multi-modal users (including pedestrians and transit users) ▪ Control of access plan for driveways and medians to prevent conflicts and collisions ▪ Build sidewalks where sidewalks are missing ▪ Improved amenities such as lighting, signing, and landscaping	Reductions in number of injuries and severity	Local and non-local automobile users; pedestrians	Fewer, and less severe crashes	$9,986,360	11

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternatives	Type of Impacts	Population Affected by Impacts	Benefits	Summary of Results Discounted 7%*	Page #
Traffic Congestion / Travel Delays ▪ System not connected to City's traffic management center ▪ Inconsistent typical section/lanes along corridor ▪ Outdated signal hardware (incompatible with TSP) ▪ No detection for multi-modal users	**Implementation of Intelligent Transportation System and roadway improvement** ▪ Connect signal controls/communications with City's traffic management center ▪ Manage corridor for multi-modal demands (including transit operations and TSP) ▪ Upgrade signalized intersections and provide pedestrian signals	Reductions in vehicle travel times and vehicle miles travels	Automobile and transit users On Dixie Highway	Pavement maintenance cost savings**	$17,305	15
				Travel time savings	$6,371,577	19
				Vehicle operating cost savings	$14,141,919	19
				Reductions in Air Emissions	$273,261	22
Transit Service Not Meeting All Needs ▪ Undesirable travel times due to slow arterial speeds ▪ Corridor is not transit/pedestrian friendly due to lack of sidewalks ▪ Lack of accessible stops and appropriate access to stops as per ADA	**Introduction of Bus Rapid Transit** ▪ Increased frequency/headways to accommodate mobility demands ▪ Approximately 36 highly visible and easily accessible transit station stops ▪ Improved accessible to transit by constructing ADA sidewalks pads at new stop locations	Diversion of auto users to transit; reduced travel times along corridor	Automobile and transit users On Dixie Highway	Pavement maintenance cost savings**	See above *(combined)*	
				Travel time savings	See above (*combined*)	
				Vehicle operating cost savings	See above (*combined*)	
				Reductions in Air Emissions	See above (*combined*)	

**All dollar values are in 2014 dollars, discounted to 2015, with a 7 percent discount rate*
*** Also included in this BCA, is the residual value of the improvements, valued at $283,878, discounted at 7 percent. See page 15.*

The period of analysis used in the estimation of benefits and costs corresponds to 34 years, including 3.5 years of construction and 30 full years of operation. The total project costs are $28.9 million dollars and are expected to be financed by Federal, State, local and private funds according to the distribution shown in Table ES-2.

Table ES-2: Project Costs and Anticipated Funding Sources, in Dollars of 2014

Item	No.	Units	Unit Cost	Cost		Funding Source
Bus Rapid Transit						
Enhanced Stops	36	stations	$100,000	$4,680,000	*	TIGER request, State/Local
Bus Only Infrastructure (lanes, etc.)	20	stations	$125,000	$3,250,000	*	
Upgraded Buses	8	each	$500,000	$4,000,000		
			Subtotal	**$11,930,000**		
Complete Streets and Safety/Access Management						
Crums to Rockford (5 lanes existing)	1.5	miles	$2,900,000	$4,350,000		State/Local
Rockford to Greenwood (7 lanes existing)	2.2	miles	$3,250,000	$7,150,000		
			Subtotal	**$11,500,000**		
ITS / Signal System and Technology Upgrades						
Corridor & Intersection Upgrades	1	LS	$4,000,000	$5,200,000	*	TIGER request State/Local
			Subtotal	**$5,200,000**		
Program Management						
			$280,000	$280,000		State/Local
			Subtotal	**$280,000**		
			Total Order of Magnitude Cost	**$28,910,000**		

**Includes PE, Utilities and Contingency - estimated to be 30%*

A summary benefits by primary long-term criterion and costs, by year, are shown in Table ES-3 (in dollars of 2014). Based on the analysis presented in the rest of this document, the project is expected to generate $31.1 million in discounted benefits and $20.4 in discounted costs, using a 7 percent real discount rate. Therefore, the project is expected to generate a Net Present Value of $10.7million and a Benefit/Cost Ratio of 1.52.

Table ES-3: Summary of Pertinent Data, Quantifiable Benefits and Costs

Calendar Year	Total Benefits	State of Good Repair	Economic Competitive-ness	Environmental Sustainability	Safety Benefits	Agency Fare Revenue*	Total Costs Net of Agency Fare Revenue*
2015	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.20
2016	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1.60
2017	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$12.10
2018	$2.00	$0.00	$1.30	$0.00	$0.70	$0.90	$10.10
2019	$1.90	$0.00	$1.30	$0.00	$0.60	$0.90	($0.30)
2020	$1.80	$0.00	$1.20	$0.00	$0.60	$0.80	($0.30)
2021	$1.70	$0.00	$1.10	$0.00	$0.60	$0.80	($0.20)
2022	$1.60	$0.00	$1.10	$0.00	$0.50	$0.70	($0.20)

Calendar Year	Total Benefits	State of Good Repair	Economic Competitive-ness	Environmental Sustainability	Safety Benefits	Agency Fare Revenue*	Total Costs Net of Agency Fare Revenue*
2023	$1.50	$0.00	$1.00	$0.00	$0.50	$0.70	($0.20)
2024	$1.40	$0.00	$1.00	$0.00	$0.50	$0.60	($0.20)
2025	$1.40	$0.00	$0.90	$0.00	$0.40	$0.60	($0.20)
2026	$1.30	$0.00	$0.90	$0.00	$0.40	$0.50	($0.20)
2027	$1.20	$0.00	$0.80	$0.00	$0.40	$0.50	($0.20)
2028	$1.20	$0.00	$0.80	$0.00	$0.40	$0.50	($0.10)
2029	$1.10	$0.00	$0.70	$0.00	$0.40	$0.40	($0.10)
2030	$1.00	$0.00	$0.70	$0.00	$0.30	$0.40	($0.10)
2031	$1.00	$0.00	$0.70	$0.00	$0.30	$0.40	($0.10)
2032	$0.90	$0.00	$0.60	$0.00	$0.30	$0.40	($0.10)
2033	$0.90	$0.00	$0.60	$0.00	$0.30	$0.30	($0.10)
2034	$0.80	$0.00	$0.60	$0.00	$0.30	$0.30	($0.10)
2035	$0.80	$0.00	$0.50	$0.00	$0.30	$0.30	($0.10)
2036	$0.80	$0.00	$0.50	$0.00	$0.20	$0.30	($0.10)
2037	$0.70	$0.00	$0.50	$0.00	$0.20	$0.30	($0.10)
2038	$0.70	$0.00	$0.50	$0.00	$0.20	$0.20	($0.10)
2039	$0.60	$0.00	$0.40	$0.00	$0.20	$0.20	($0.10)
2040	$0.60	$0.00	$0.40	$0.00	$0.20	$0.20	($0.10)
2041	$0.60	$0.00	$0.40	$0.00	$0.20	$0.20	($0.10)
2042	$0.50	$0.00	$0.40	$0.00	$0.20	$0.20	($0.10)
2043	$0.50	$0.00	$0.30	$0.00	$0.20	$0.20	($0.10)
2044	$0.50	$0.00	$0.30	$0.00	$0.20	$0.20	($0.10)
2045	$0.50	$0.00	$0.30	$0.00	$0.10	$0.20	$0.00
2046	$0.40	$0.00	$0.30	$0.00	$0.10	$0.10	$0.00
2047	$0.40	$0.00	$0.30	$0.00	$0.10	$0.10	$0.00
2048	$0.40	$0.00	$0.30	$0.00	$0.10	$0.10	$0.00
2049	$0.30	$0.30	$0.00	$0.00	$0.00	$0.00	$0.00
Total	**$31.10**	**$0.30**	**$20.50**	**$0.30**	**$10.00**	**$12.40**	**$20.40**

* Fare revenues, or "Agency Benefits", are added to total benefits to offset the (transfer) payments made by transit users as part of the general cost of travel and to avoid double-counting the portion of the project costs paid for indirectly through fares (once as a user cost in the estimation of consumer surplus, and a second time as direct project costs in the estimation of operating and maintenance (O&M) and other expenses.

In addition to the monetized benefits presented in Table ES-3, the project would generate benefits that are difficult to quantify. A brief description of those benefits is provided below.

Improved access to employment, social services, education, and medical care for low and moderate income residents supporting increasing employment, income and health. The three project elements (ITS/Signal System Technology Upgrades, Complete Streets and Safety/Access Management, and BRT) combine to significantly improve resident's mobility and access to employment, social services, education, and medical care throughout the corridor. The BRT service will end in downtown Louisville, where jobs, services and medical care are clustered. Additional, smaller employment clusters are located at key intersections along Dixie Highway, and to the east and west of the corridor along major intersecting roadways (such as the Riverport Industrial Park). Numerous hospitals and clinics are located within a half mile of the corridor, with several in downtown (University of Louisville Sports Medicine, James Graham Brown Cancer Center, and Norton Hospital Center and Kosair Children's Hospital, Kentucky's only free-standing full-service children's hospital). The YMCA is to break ground later in 2015 on the site of an old cigarette manufacturing. Greater and easier access for low and moderate income families may result in some increasing levels of employment, income and/or overall health

Encourage Commercial Activity and Economic Growth. The street improvements planned for the central section of the corridor near the Watterson Expressway will significantly improve pedestrian safety, aesthetics, and access to businesses along Dixie Highway. This will support additional customer traffic, fostering increased economic activity. The BRT will also promote economic activity in the vicinity of the major stations

2. Introduction

This document provides detailed technical information on the economic analyses conducted in support of the Grant Application for the Transforming Dixie Highway project.

Section 3, Methodological Framework, introduces the conceptual framework used in the Benefit-Cost Analysis (BCA). Section 4, Project Overview, provides an overview of the project, including a brief description of existing conditions and proposed alternatives; a summary of cost estimates and schedule; and a description of the types of effects that the Transforming Dixie Highway project is expected to generate. Section 5, General Assumptions, discusses the general assumptions used in the estimation of project costs and benefits, while estimates of travel demand and traffic growth can be found in Section 6, Demand Projections. Specific data elements and assumptions pertaining to the long-term outcome selection criteria are presented in Section 7, Benefits Measurement, Data and Assumptions, along with associated benefit estimates. Estimates of the project's Net Present Value (NPV), its Benefit/Cost ratio (BCR) and other project evaluation metrics are introduced in Section 8, Summary of Findings and BCA Outcomes. Next, Section 9, BCA Sensitivity Analysis, provides the outcomes of the sensitivity analysis. Additional data tables are provided in Section 10, Supplementary Data Tables, including annual estimates of benefits and costs, as well as intermediate values to assist DOT in its review of the application.[1]

[1] While the models and software themselves do not accompany this appendix, greater detail can be provided, including spreadsheets presenting additional interim calculations and discussions on model mechanics and coding, if requested.

3. Methodological Framework

Benefit-Cost Analysis (BCA) is a conceptual framework that quantifies in monetary terms as many of the costs and benefits of a project as possible. Benefits are broadly defined. They represent the extent to which people impacted by the project are made better-off, as measured by their own willingness-to-pay. In other words, central to BCA is the idea that people are best able to judge what is "good" for them, what improves their well-being or welfare.

BCA also adopts the view that a net increase in welfare (as measured by the summation of individual welfare changes) is a good thing, even if some groups within society are made worse-off. A project or proposal would be rated positively if the benefits to some are large enough to compensate the losses of others.

Finally, BCA is typically a forward-looking exercise, seeking to anticipate the welfare impacts of a project or proposal over its entire life-cycle. Future welfare changes are weighted against today's changes through discounting, which is meant to reflect society's general preference for the present, as well as broader inter-generational concerns.

The specific methodology developed for this application was developed using the above BCA principles and is consistent with the TIGER guidelines. In particular, the methodology involves:

- Establishing existing and future conditions under the build and no-build scenarios;
- Assessing benefits with respect to each of the five long-term outcomes identified in the Notice of Funding Availability (NOFA);
- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement;
- Using DOT guidance for the valuation of travel time savings, safety benefits and reductions in air emissions, while relying on industry best practice for the valuation of other effects;
- Discounting future benefits and costs with the real discount rates recommended by the DOT (7 percent, and 3 percent for sensitivity analysis); and
- Conducting a sensitivity analysis to assess the impacts of changes in key estimating assumptions.

4. Project Overview

The Transforming Dixie Highway Project was envisioned from this Dixie Highway Corridor Master Plan, taking several of the recommended transformational improvements and building consensus with the project partners on the current project components. It includes three primary elements:

- ITS / Signal System and Technology Upgrades;
- Complete Streets and Safety/Access Management Improvements; and
- Bus Rapid Transit (BRT)

Specifically, the ITS and signal system improvements will incorporate new technology connecting Dixie Highway to the city's existing upgraded traffic operations center for active traffic management operations. It will also include transit signal priority equipment and signal phasing improvements to speed BRT travel.

The Complete Streets and Safety/Access Management improvements will include constructing pedestrian pathways and improved multi-modal (especially pedestrian and transit) connectivity in critical areas to help achieve the city and community's complete streets, livability, and development objectives. While bicycle facilities are often provided in complete streets corridors, they are currently being evaluated for separate facilities that run generally parallel to Dixie. The safety and access management aspects of the project include raised medians and driveway consolations, turn lanes, signage and striping upgrades, and other safety enhancements.

The BRT will include upgraded transit facilities along the entire length of the corridor with approximately 36 new, highly visible and easily accessible BRT stations, newly branded vehicles unique to the Dixie Highway corridor, appropriately located queue-jump lanes and bus turnouts, These elements will facilitate safe and efficient travel and will help the community achieve its stated community character and development goals.

4.1 Base Case and Alternative

The project's impacts, costs and benefits are measured against a base case in which existing maintenance levels are maintained, current bus routes retain their current scheduled, and no ITS improvements occur along the corridor. Additionally, city population growth and ridership increases at rates in line with recent trends. The potential impacts of future develop on demand for transit services are not estimated either under the base case or the build scenario.

The 'build scenario' being assessed here includes:

1. ITS / Signal System and Technology Upgrades: Intelligent Transportation System (ITS) communications infrastructure upgrade is proposed along Dixie Highway from the Gene Snyder Freeway to Broadway in downtown Louisville. The system will include a reliable, robust hard wired fiber optic trunk line that will not only serve as a communications link to each of the traffic signals, but will provide future communications for intersecting streets, cameras, dynamic message signs and other future ITS systems and equipment.

   The project initiative includes the upgrade, replacement and rehabilitation of traffic and pedestrian signal displays, controller equipment and associated hardware at approximately half of the traffic signals along the corridor. It is envisioned that all new pedestrian signals will be upgraded to count-down type displays thus bringing all of the traffic signals into compliance with current federally mandated guidelines identified in the Manual on Uniform Traffic Control Device (MUTCD).

2. Complete Streets and Safety/Access Management Improvements: The proposed projects will include reconstruction of the entire roadway section to improve safety

and provide increased control of access by consolidating entrances (where possible) and converting the existing two-way left-turn lane (TWLTL) into one-way left turn lanes with a raised, landscaped median. Additional improvements would include new ADA-compliant sidewalks, landscaping, enhanced lighting and updated roadway amenities.

It is anticipated that additional low cost safety and operational improvements will also be provided as part of the project in the high crash rate section from Crums Lane north to Broadway. These improvements are expected to include restriping to provide left turn lanes, new crosswalk markings, as well as other signage and striping upgrades. These enhancements will benefit the BRT operations as well as pedestrian and auto safety.

3. Bus Rapid Transit (BRT): The proposed BRT service will begin in downtown Louisville (near the intersection of 2nd Street/Main Street) and generally follow the alignment of TARC's existing Route 18 along Main Street/Market Street to 18th Street; then on 18th and Dixie Highway to the Gene Snyder Freeway. The BRT will include approximately 36 new, highly visible and easily accessible BRT stations and use newly branded vehicles that are unique to the Dixie Highway BRT. Traffic signal priority (TSP) and queue-jump lanes with bus turnouts (at approximately half of the stop locations) will be provided at intersections along the corridor, as well as real-time information for transit customers at each enhanced station location. It is anticipated that the existing Route 18 would continue to provide local service with more frequent stops along the corridor, supplementing the higher speed BRT.

4.2 Types of Impacts and Affected Population

Transforming Dixie Highway builds and strengthens A Ladder of Opportunity for Louisville's low, moderate and minority income neighborhoods in the southwestern part of the city. The Dixie Highway corridor is approximately 14.9 miles long and home to nearly 50,000 residents, many of whom are low to moderate income households, transit dependent, and have the lowest life expectancy rates in all of Louisville. Median household income along the corridor was $30,952 in 2012, compared to $50,157 for all U.S. households. Nearly 9% of the corridor's residents use public transportation as their primary means of travel to work compared to 3.4% for the rest of Louisville.

The project will **improve mobility and access to employment, social services, education, and medical care** for residents along the corridor, many of whom are minority or moderate income households, as well as for the suburban communities at the southwestern edge of the city.

The project will also **significantly improve safety for pedestrians and automobiles**. This is particularly important in the low-income neighborhoods in the north where the crash rate is the highest in the corridor.

The street improvements planned for the central section of the corridor near the Watterson Expressway will significantly improve pedestrian safety, aesthetics, and access to businesses along Dixie Highway. This will support additional customer traffic, **fostering increased economic activity**. The BRT will also promote economic activity in the vicinity of the major stations.

The improvements will also help improve the **quality of life** of neighborhoods adjacent to the corridor due to improved mobility, greater safety, lower emissions, and increased economic activity.

4.3 Project Cost and Schedule[2]

Project costs begin in late 2015, with preliminary design and public involvement, and end in 2018. The majority of costs are incurred in 2017 and 2018.

Table 1: Project Schedule

	2015				2016				2017				2018			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
ITS / Signal System and Technology Upgrades					P	D	D		C	C	C	C	C	C	C	
Bus Rapid Transit				P	P	P	D	D		C	C	C	C	C		
Complete Streets & Safety/Access Mgmt.																
Crums to Rockford				P	P	P	D	D	D		C	C	C			
Rockford to Greenwood					P	P	P	D	D	D		C	C	C	C	

P	Preliminary Design and Public Involvement
D	Final Design
C	Construction

4.4 Disruptions Due to Construction

The Project may have short-term construction impacts on traffic. Detours for access during construction are expected to create minimal traffic delays. No disruptions to traffic and parking are included in the BCA.

4.5 Effects on Long-Term Outcomes

The main benefit categories associated with the project are mapped into the five long-term outcome criteria set forth by the DOT in the table below.

[2] All cost estimates in this section are in millions of dollars of 2014, discounted to 2015 using a 7 percent real discount rate.

Table 2: Expected Effects on Long-Term Outcomes and Benefit Categories

Long-Term Outcomes	Benefit or Impact Categories	Description	Monetized	Quantified	Qualitative
State of Good Repair	Pavement Maintenance Cost Savings	Reductions in pavement maintenance costs due to changes in roadway usage	X		
Economic Competitiveness	Travel Time Savings	Travel time savings from reduced congestion and improved signalization	X		
	Vehicle Operating Cost Savings	Reduction in out-of-pocket costs to drivers switching to public transit	X		
Quality of Life	Noise reduction	Reductions in automobile travel times and miles traveled will result in less traffic noise for nearby residents			X
	Improve the “walkability” and connections among area residents	Sidewalks and safer intersections and ADA compliant elements will enhance connectivity and pedestrian usage			X
	Spur increased commercial activity	BRT and street scape improvements will make corridor more attractive to foot traffic for stores			X
	Improved Mobility / Ladder of Opportunity	BRT and congestions mitigation provides more and faster to employment, social services, education, and medical care			X
Environmental Sustainability	Emission Cost Savings	Reductions in greenhouse gas and air pollutant emissions due to changes in auto use	X		
Safety	Accident Cost Savings	Reductions in property losses, injuries and deaths due to changes in VMT and safety improvements	X		

5. General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of construction and including 30 years of operations.

The monetized benefits and costs are estimated in 2014 dollars with future dollars discounted in compliance with TIGER requirements using a 7 percent real rate, and sensitivity testing at 3 percent.

The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically:

- Input prices are expressed in 2014 dollars;
- The period of analysis begins in 2016 and ends in 2048. It includes project development and construction years (2015-2018) and 31 years of operations (2018 - 2048);
- A constant 7 percent real discount rate is assumed throughout the period of analysis. A 3 percent real discount rate is used for sensitivity analysis;
- Opening year demand is an input to the BCA and is assumed to be fully realized in Year 1 (no ramp-up); and
- Unless specified otherwise, the results shown in this document correspond to the effects of the Full Build alternative (which includes 36 BRT stops).

6. Demand Projections

Demand projections for the BRT are important in estimating the long-term impacts of this project. Spreadsheets with detailed data regarding the demand projects are located at: https://louisvilleky.gov/government/advanced-planning/transforming-dixie-highway.

6.1 Assumptions

Certain assumptions were made in order to estimate demand. One was made by HDR, based on the professional experience of its transit planners; others were provided by Kentucky Indiana Planning and Development Agency (KIPDA), the local MPO. These are summarized in the table below:

Table 3: Assumptions used in the Estimation of Demand

Variable Name	Unit	Value	Source
Diversion from Auto	%	50%	HDR assumption
Passenger Vehicle Occupancy Rate	Persons per Vehicle	1.62	KIPDA
Average Trip Length	Mile	5.1	KIPDA
Average Vehicle Trip Duration	Minute	18.41	KIPDA

6.2 Demand Projections

As presented in Table 4, approximately half of the BRT total ridership is diverted from autos. Table 4 also presents the resulting reduction in vehicle miles traveled (VMT) and vehicle hours traveled (VHT) due to the diversion of auto riders to the BRT in the opening year, 2018, and in 2048.

Table 4: Demand Projections

	In Project Opening Year	
	2018	2048
BRT Ridership	593,813	606,410
Diverted from Auto	296,906	303,205
Reduction in VMT	934,705	954,535
Reduction in VHT	56,235	57,428

7. Benefits Measurement, Data and Assumptions

This section describes the measurement approach used for each benefit or impact category identified in Table 2 (Expected Effects on Long Term Outcomes and Benefit Categories) and provides an overview of the associated methodology, assumptions, and estimates.

7.1 State of Good Repair

To quantify the benefits associated with maintaining the Dixie Highway corridor in a state of good repair, the impacts on the life-cycle pavement maintenance costs as well as the residual value of the project at the end of the analysis period (2048) were calculated per US DOT guidance.

7.1.1 Methodology

Pavement maintenance cost savings are a function of the estimated reduction in VMT and are calculated as the difference between pavement maintenance costs in the no-build and the build scenarios.

The residual value of the project implies that these investments in the Dixie Highway corridor will have significant value beyond the 30-year operation period within the BCA. It is calculated using a straight line depreciation method and assuming no salvage value at the end of the project/building's useful life (40 years).

7.1.2 Assumptions

The assumptions used in the estimation of State-of-Good-Repair benefits are summarized in the table below.

Table 5: Assumptions used in the Estimation of State-of-Good-Repair Benefits

Variable Name	Unit	Value	Source
Pavement Maintenance Cost	$ per VMT	$0.0014	US DOT, *Addendum to the 1997 Federal Highway Cost Allocation Study Final Report* (May 2000)
Useful Life of Asset	Year	40	HDR assumption

7.1.3 Benefit Estimates

The undiscounted pavement maintenance cost savings are estimated at $1,568 in the opening year and $49,189 over the analysis period. Results by calendar year of operation are shown in Section 10.3. Using a 7 percent discount rate, the lifecycle benefits from pavement maintenance cost savings amount to $17,305.

The project's residual value at the end of the analysis period is estimated at $301,182 using a 7 percent discount rate.

Table 6: Estimates of State-of-Good-Repair Benefits, Millions of 2014 Dollars

	In Project Opening Year	Over the Project Lifecycle	
	2018	In Constant Dollars	Discounted at 7 Percent
Pavement Maintenance Cost Savings	$1,568	$49,189	$17,305
Residual Value	$0	$2,832,563	$283,878
Total	**$1,568**	**$2,881,752**	**$301,182**

7.2 Economic Competitiveness

The proposed project would contribute to enhancing the economic competitiveness of the Nation through improvements in the mobility of people and goods within and across the study area. In this analysis, two measures of mobility are presented: travel-time savings and out-of-pocket transportation cost savings.

7.2.1 Methodology

The framework used in the estimation of user benefits is based upon the theory of demand and involves the estimation of changes in consumer surplus.

The demand for travel is an inverse relationship between the number of trips "demanded" and the generalized cost of travel, which includes both travel time and out-of-pocket costs (such as vehicle operating and parking costs for auto users, or fare payments for transit riders). That relationship is depicted in Figure 1 on the next page. The term "consumer surplus" refers to the area between the demand curve and the actual cost of travel at any point in time. It is a measure of welfare to the extent that people who are traveling at that cost are "paying" less than what they would be willing to pay; in other words the value they are placing on a trip (as measured by their willingness-to-pay along the demand curve) is higher than what they are actually paying.

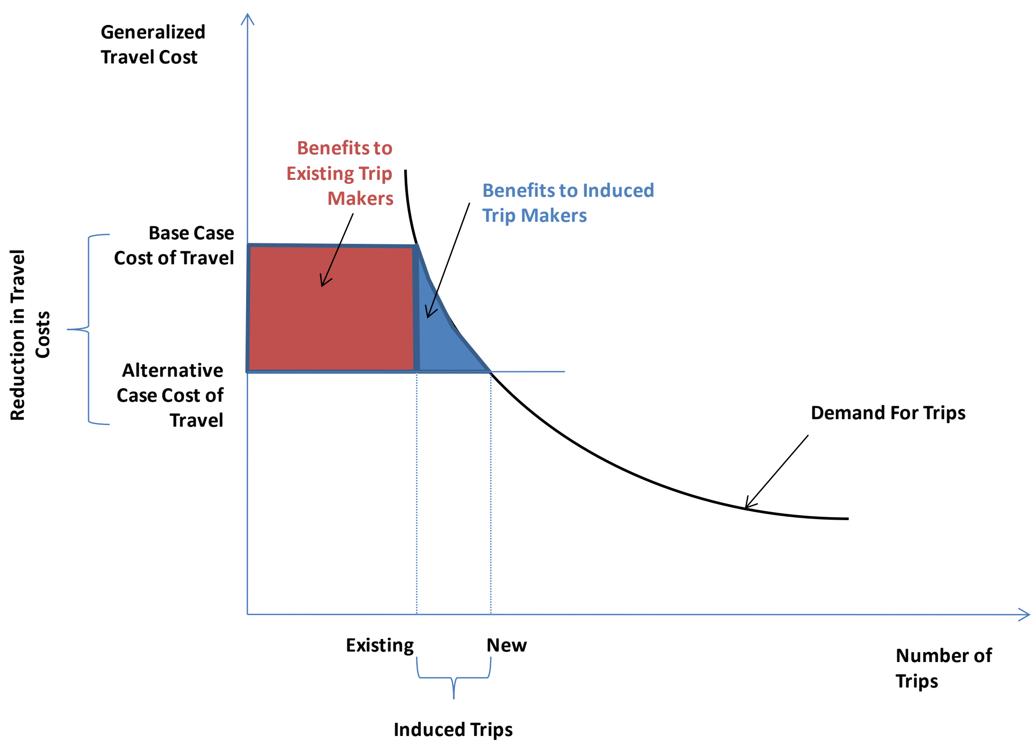
The proposed project will reduce the general cost of travel and result in benefits to both exiting and new trip-makers.

Benefits to existing trip-makers are represented by the red rectangle in Figure 1. They are estimated as the difference between the generalized cost of travel in the base case and the generalized cost of travel in the build scenario times the number of existing trips.

In addition, as the generalized cost of travel is being reduced, additional trips (beyond those diverted from other modes) are expected. These induced trip-makers represent a portion of all potential trip-makers who did not make a trip (or as many trips) in the no-build scenario, but are now “attracted” to the lower generalized cost allowed by the investment.

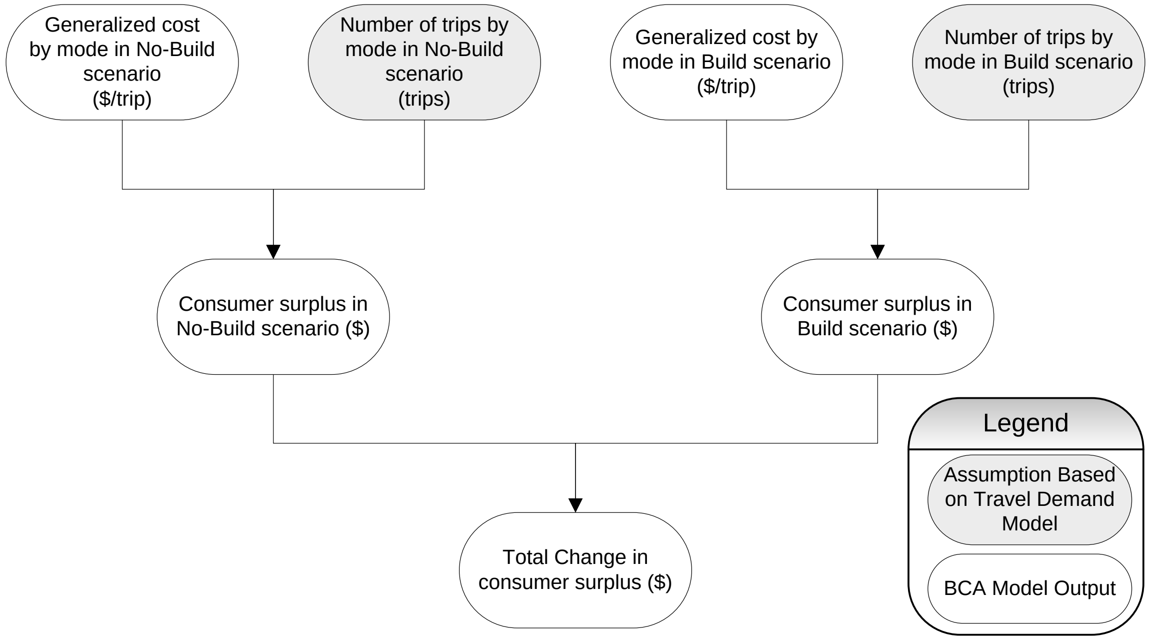
User benefits resulting from new trips are depicted by the blue triangle in Figure 1. They are estimated using the “rule-of-a-half”. Note that the change in generalized cost from no-build to build conditions only represents the change in user costs (travel time plus out-of-pocket costs). Social costs, including air emissions, accident occurrences and congestion externalities are assumed not to affect trip making or modal decisions in this analysis. The elasticity of demand (the slope of the demand curve) is estimated based on existing knowledge about travel costs in the corridor and ridership forecasts developed for the project.

Figure 1: Framework for the Estimation of User Benefits



The steps involved in the calculation of user benefits are illustrated through a structure and logic diagram in Figure 2 below.

Figure 2: Structure and Logic Diagram for Estimating Change in User Benefits



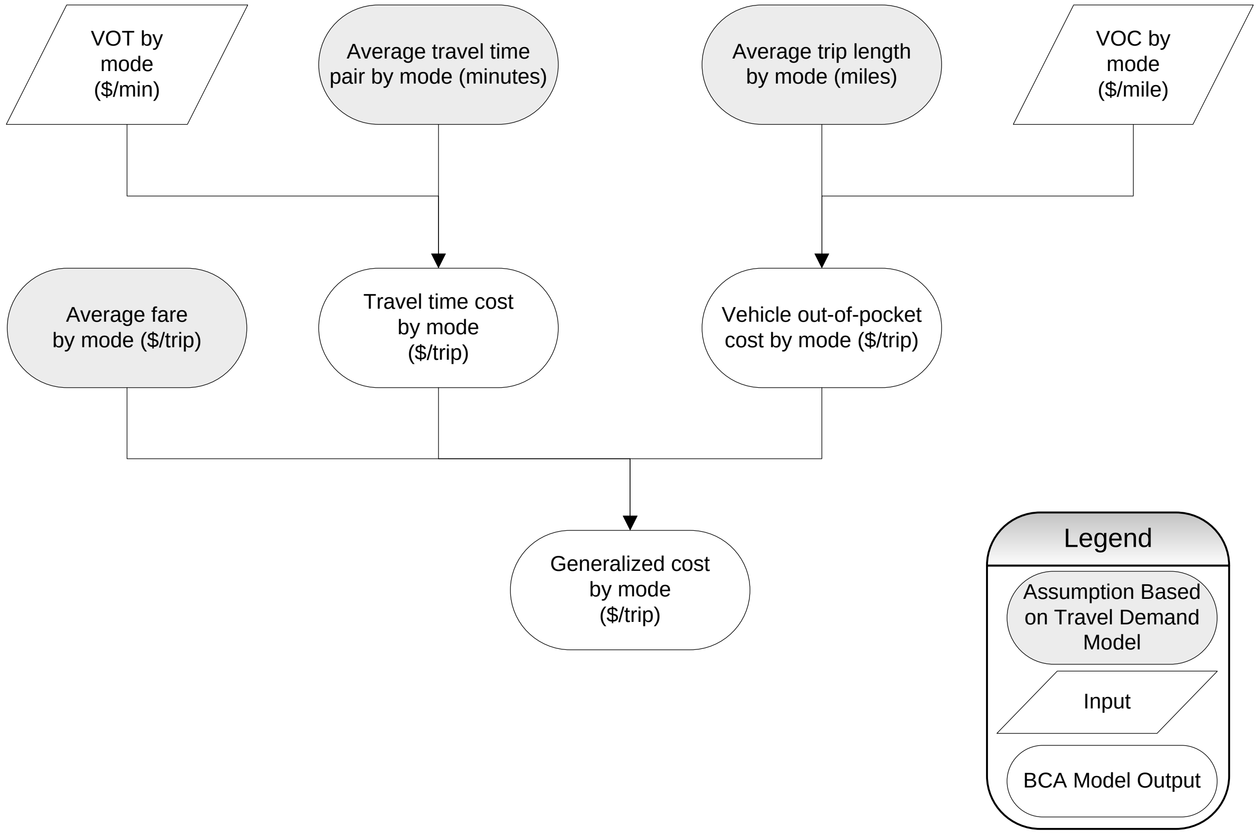
Generalized travel cost has two components: travel time cost and out-of-pocket transportation costs. Travel time savings for travelers are dependent on their value of time (VOT) and the reduction of time spent on traveling (travel time).

Once the project is complete, some car drivers will experience a reduction in travel time as a result of less congestion. Travelers who divert from autos to buses might also experience a reduction in travel time depending on their origin and destination. VOT is then applied to each reduction in travel time to estimate the reduction in travel time costs.

Out-of-pocket costs are composed of four vehicle operating costs: fuel, oil, tires, maintenance and depreciation. The consumption rates for these costs are derived from average vehicle speed and combined with unit cost estimates to derive total out-of-pocket costs per mile and per trip. The out-of-pocket costs are combined with parking cost to estimate the total out-of-pocket cost per trip for auto users. The decrease in out-of-pocket costs in the build scenario represents out-of-pocket cost savings for remaining auto users. For travelers who divert from auto to buses, the out-of-pocket savings are estimated by subtracting fare payments from out-of-pocket costs.

Figure 3 below illustrates the structure and logic of the generalized travel cost calculation.

Figure 3: Structure and Logic Diagram for Calculating the Generalized Travel Cost



7.2.2 Assumptions

As described above, travel time savings are computed using VOT estimates from the US DOT and the estimated reduction in travel time resulting from the project. US DOT provides VOT estimates for both personal and business trips. The average passenger vehicle occupancy rate and average trip length in the study area are provided by KIPDA, the regional MPO.

The assumptions used in the estimation of travel time savings are summarized in the table below.

Table 7: Assumptions used in the Estimation of Travel Time Savings

Variable Name	Unit	Value	Source
Passenger Vehicle Occupancy Rate	Persons per Vehicle	1.62	KIPDA
Travel Time Cost – Personal Travel	Dollars per Hour	$12.70	US DOT, *TIGER Benefit-Cost Analysis Resource Guide* (Updated 3/27/15)
Travel Time Cost – Business Travel	Dollars per Hour	$24.80	
Weighted Average Travel Time Cost	Dollars per Hour	$13.21	HDR Calculation
Real Annual Growth Rate of Value of Time	Percent	1.20%	US DOT, *Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis* (July 2014)
Average Trip Length	Mile	5.1	KIPDA

Out-of-pocket costs are calculated using consumption rates for fuel, oil, tires, maintenance and depreciation from the Highway Economic Requirements System – State Version (HERS-ST) and unit costs from US DOT. The table below lists these unit costs along with the average bus fare per trip.

Table 8: Assumptions used in the Estimation of Out-of-Pocket Travel Cost Savings

Variable Name	Unit	Value	Source
Vehicle Operating Costs – Fuel*	$ per Gallon	Varies	Energy Information Administration, *Annual Energy Outlook 2015* (April 2015)
Vehicle Operating Costs – Oil	$ per Quart	$9.96	US DOT, FHWA HERS-ST
Vehicle Operating Costs – Tires	$ per Tire	$91.35	US DOT, FHWA HERS-ST
Vehicle Operating Costs – Maintenance	$ per 1,000 Miles	$166.94	US DOT, FHWA HERS-ST
Vehicle Operating Costs – Depreciation	$ per Vehicle	$21,787	US DOT, FHWA HERS-ST
Average BRT Fare	$ per Trip	$2.75	TARC
Average Bus Fare	$ per Trip	$1.75	TARC

** The real cost of fuel varies over time (based on projections from the Energy Information Administration's Annual Energy Outlook 2015).*

7.2.3 Benefit Estimates

The table below shows the lifecycle transportation costs savings calculated for roadway users as well as for existing and induced bus riders. These cost savings are estimated to total $60.3 million, discounted at 7 percent. The majority of the benefits ($43.0 million) are travel time savings. Out-of-pocket cost savings are estimated at $18.6 million.

Table 9: Estimates of Travel Time and Out-of-Pocket Cost Savings, Millions of 2014 Dollars

	In Project Opening Year	Over the Project Lifecycle	
	2018	In Constant Dollars	Discounted at 7 Percent
Travel Time Cost Savings	$537,872	$18,627,978	$6,371,577
Out-of-Pocket Savings	$1,086,000	$43,718,145	$14,141,919
Total	**$1,623,872**	**$62,346,123**	**$20,513,496**

7.3 Quality of Life

People place a value on their assessment of the quality of life in an area, which can include a sense of equity and fairness in the area, of overall attractiveness of the physical place and a sense of community cohesiveness. These aspects are significantly influenced by individuals' mobility and relation to the surrounding community as well as the accessibility of and goods and services.

Although not monetized in this BCA, the Transforming Dixie Highway project is expected contribute to enhancing livability and quality of life along the corridor through in several ways:

- Reduced congestion will lead to reduced noise (as well as to the reduction in emissions estimated in the safety section below).
- The addition for streetscaping elements, including sidewalks and safer intersections and ADA compliant sidewalks and stops will improve the "walkability" in the center of the corridor and enhance the connectivity of adjacent neighborhoods.
- The addition of the BRT combined with the street scape improvements, will increase the attractiveness of the corridor for new commercial activity.
- Improved mobility and access to clusters of employment, social services, education, and medical care for residents along the corridor, especially those low and moderate and minority residents along the corridor's northern end.

7.4 Environmental Sustainability

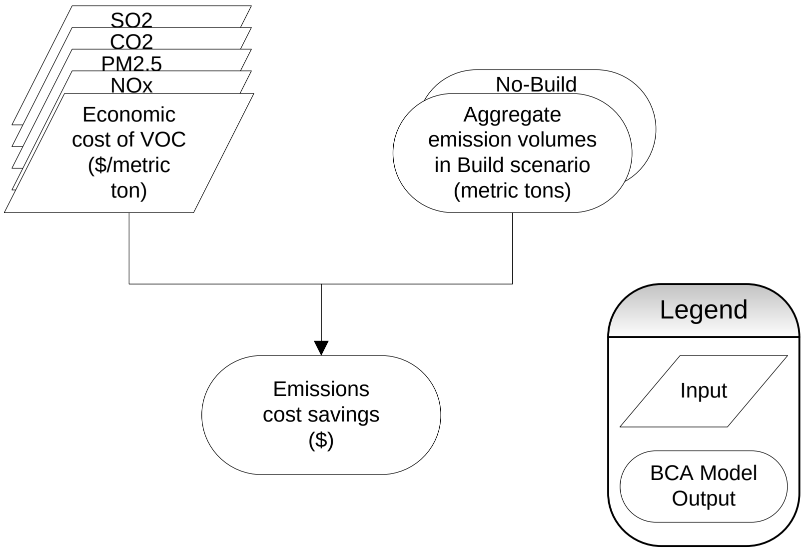
The proposed project would contribute to environmental sustainability through reduced usage of motorized vehicles - lower VMT will result in lowered emissions – and green components of the new streetscape, which would capture storm water prior to entry into the combined sewer and provide means for infiltration treatment.

In this BCA, only the benefits from reductions in emission are monetized. Two categories of environmental impacts are considered for this project: reductions in carbon emissions and reductions in non-carbon emissions. Carbon emissions are measured in carbon dioxide (CO_2) equivalent and non-carbon emissions include volatile organic compounds (VOC), nitrogen oxides (NO_x), sulfur dioxide (SO_2) and fine particulate matter ($PM_{2.5}$).

7.4.1 Methodology

Reductions in emission volumes are derived based upon the reduction in VMT resulting from diversion to public transit and the improved travel times due to the proposed signal coordination. Emission rates for Louisville were obtained from Motor Vehicle Emission Simulator (MOVES) – a tool provided by the U.S. Environmental Protection Agency (EPA). Per-unit emission costs are applied to the emission reduction volumes due to the reduction in VMT caused by modal shifts. Figure 4 below, describes the structure and logic of the estimation of emissions cost savings.

Figure 4: Structure and Logic Diagram for Estimating Emissions Cost Savings



7.4.2 Assumptions

The assumptions used in the estimation of environmental sustainability benefits are summarized in the table below.

Table 10: Assumptions used in the Estimation of Environmental Sustainability Benefits

Variable Name	Unit	Value	Source
Cost of Carbon Emissions	$ per Metric Ton	Varies*	US DOT, *TIGER Benefit-Cost Analysis Resource Guide* (Updated 3/27/15)
Cost of VOC Emissions	$ per Metric Ton	$2,031	
Cost of PM2.5 Emissions	$ per Metric Ton	$366,229	
Cost of SO2 Emissions	$ per Metric Ton	$47,316	
Cost of NOx Emissions	$ per Metric Ton	$8,005	

** The social cost of carbon increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater levels of climatic change.*

7.4.3 Benefit Estimates

Table 11 presents the monetized values of expected reductions in emissions in 2018 and over the lifecycle of the project. In the first year emissions cost savings are relatively small 28,438. Over the project lifecycle, emissions cost savings total $273,261, discounted at 7 percent.

Table 11: Estimates of Environmental Sustainability Benefits, Millions of 2014 Dollars

	In Project Opening Year	Over the Project Lifecycle	
	2018	In Constant Dollars	Discounted at 7 Percent
Sulfur Dioxide (SO2)	$58	$423	$218
Fine Particulate Matter (PM2.5)	$1,553	$9,534	$5,585
Volatile Organic Compounds (VOC)	$1,739	$22,990	$10,199
Nitrogen Oxides (NOx)	$339	$4,453	$1,966
Carbon (CO2)	$24,750	$700,637	$255,293
Total	**$28,438**	**$738,036**	**$273,261**

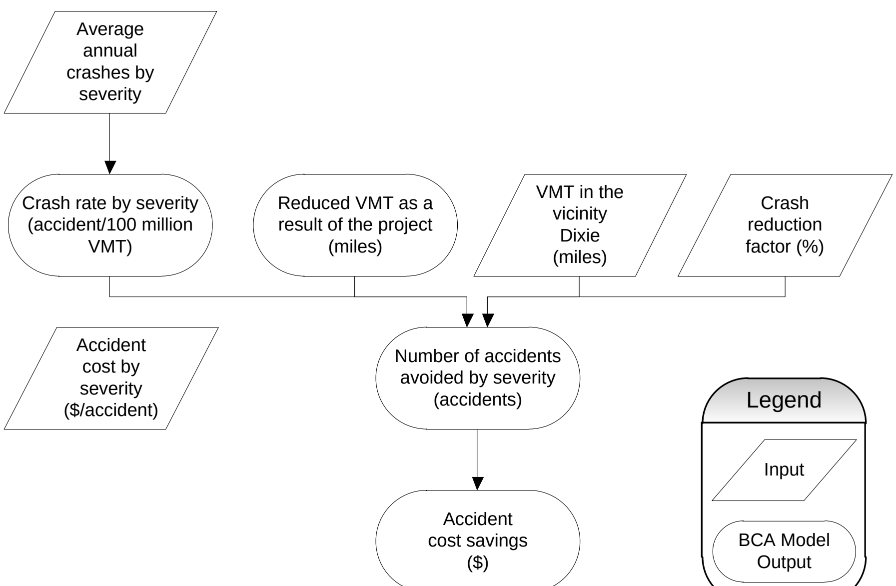
7.5 Safety

The Transforming Dixie Highway would significantly contribute to promoting DOT's safety long-term outcome by leading to substantial reductions in accidents.

7.5.1 Methodology

The figure below shows the methodology used to estimate accident cost savings from the project. Historical crash data for the study area from 2009 to 2013 were compiled by crash severity.

Figure 5: Structure and Logic Diagram for Estimating Accident Cost Savings



7.5.2 Assumptions

The assumptions used in the estimation of safety benefits are summarized in the table below.

Table 12: Assumptions used in the Estimation of Safety Benefits

Variable Name	Unit	Value	Source
Minor (AIS 1)	$ per Injury	$28,657	US DOT, *TIGER Benefit-Cost Analysis Resource Guide* (Updated 3/27/15)
Moderate (AIS 2)	$ per Injury	$448,967	
Serious (AIS 3)	$ per Injury	$1,003,011	
Severe (AIS 4)	$ per Injury	$2,540,961	
Critical (AIS 5)	$ per Injury	$5,664,624	
Fatal (AIS 6)	$ per Injury	$9,552,486	
Property Damage Only (PDO)	$ per Accident	$3,991	
Annual Growth in Accident Cost	%	1.2%	

7.5.3 Benefit Estimates

Based on the assumptions presented above, the project will result in a net lifecycle safety benefit of nearly $10.0 million, discounted at 7 percent. A summary of the results is presented in Table 13. Complete results by calendar year of operation are shown in Section 10.7.

Table 13: Estimates of Safety Benefits, Millions of 2014 Dollars

	In Project Opening Year	Over the Project Lifecycle	
	2018	In Constant Dollars	Discounted at 7 Percent
Accident Cost Savings	$800,921	$30,149,946	$9,986,360

8. Summary of Findings and BCA Outcomes

The tables below summarize the BCA findings. Annual costs and benefits are computed over the lifecycle of the project (34 years). As stated earlier, construction is expected to be completed by 2018. Benefits accrue during the full operation of the project (through 2048).

Table 14: Overall Results of the Benefit Cost Analysis*

Project Evaluation Metric	7% Discount Rate	3% Discount Rate
Total Discounted Benefits (Millions of $2014)	$31.1	$56.0
Total Discounted Costs (Millions of $2014)	$20.4	$19.8
Net Present Value (Millions of $2014)	$10.7	$36.2
Benefit-Cost Ratio	1.52	2.83
Internal Rate of Return (%)	10.8%	
Payback Period (years)	12	

**Note: these results are slightly lower than those presented in the application. When preparing the annual tables, an error was found in the outer years benefits estimation and in estimate of operations and maintenance costs. After correcting for those errors, both lifecycle costs and benefits declined, and the benefit-cost ratio changed from 2.1 to 1.52, discounted at 7 percent, and from 3.0 to 2.83, discounted at 3 percent. The project remains economically efficient.*

Considering all monetized benefits (user as well as non-user) and costs (capital as well as operating and maintenance costs), the estimated internal rate of return of the project is estimated at 10.8 percent. With a 7 percent discount rate, the project would result in a net present value of nearly $10.7 million and a benefit-cost ratio of 1.52.[3]

With a 3 percent real discount rate, the net present value of the project would increase to $36.2 million, for a benefit-cost ratio of 2.83.

Table 15: Benefit Estimates by Long-Term Outcome

Long-Term Outcome	Benefit Category	7% Discount Rate	3% Discount Rate
State of Good Repair	Pavement Maintenance Cost Savings	$17,305	$29,864
	Residual Value	$283,878	$1,036,845
Economic Competitiveness*	Travel Time Savings	$6,371,577	$11,168,955
	Vehicle Operating Cost Savings	$14,141,919	$25,545,620
Environmental Sustainability	Reductions in Air Emissions	$273,261	$458,035
	Reduction in Noise Pollution	--	--
Safety	Reduction in Crashes	$9,986,360	$17,808,018
Sum of Benefits		**$31,074,299**	**$56,047,337**
Agency Benefits	Fare Revenue	$12,386,874	$21,375,103

*Note: * Excluding the short-term employment impacts of the project*

Included in Table 18 – along with State of Good Repair, Economic Competitiveness, Quality of Life, Environmental Sustainability and Safety benefits – are fare revenues. Fare revenues, or "Agency Benefits", are added to total benefits to offset the (transfer) payments made by transit users as part of the general cost of travel and to avoid double-counting the portion of the project costs paid for indirectly through fares (once as a user cost in the estimation of consumer surplus, and a second time as direct project costs in the estimation of operating and maintenance (O&M) and other expenses.

9. BCA Sensitivity Analysis

The BCA outcomes presented in the previous sections rely on a large number of assumptions and long-term projections; both of which are subject to considerable uncertainty.

The primary purpose of the sensitivity analysis is to help identify the variables and model parameters whose variations have the greatest impact on the BCA outcomes: the "critical variables."

[3] As noted on the table, these results are slightly lower than those presented in the application. When preparing the annual tables, an error was found in the outer years in the benefits estimation and in estimate of operations and maintenance. These results incorporate corrections to those errors, reducing both costs and benefits. The benefit-cost ratio declined from 2.1 to 1.52, discounted at 7 percent, and from 3.0 to 2.83, discounted at 3 percent. The project remains economically efficient.

The sensitivity analysis can also be used to:

- Evaluate the impact of changes in individual critical variables – how much the final results would vary with reasonable departures from the "preferred" or most likely value for the variable; and
- Assess the robustness of the BCA and evaluate, in particular, whether the conclusions reached under the "preferred" set of input values are significantly altered by reasonable departures from those values.

The outcomes of the quantitative analysis for the project using a 7 percent discount rate are summarized in the table below. The table provides the percentage changes in project NPV associated with variations in variables or parameters (listed in row), as indicated in the column headers.

For instance, the sensitivity results show that a 25 percent decrease in capital costs leads to a nearly 57.9 percent increase in the project NPV, while a 25 percent decrease in O&M costs decreases the project NPV by 19.1 percent. In all cases, the benefit-cost ratio remains well above 1.0.

Table 16: Quantitative Assessment of Sensitivity, Summary

Parameters	Change in Parameter Value	New NPV	Change in NPV	New B-C Ratio
Value of Travel Time	Lower Bound of Range Recommended by US DOT	$7.2	-32.7%	1.4
	Upper Bound of Range Recommended by US DOT	$13.1	23.0%	1.6
Value of Statistical Life	Lower Bound of Range Recommended by US DOT ($5.3 million)	$6.5	-39.1%	1.3
	Upper Bound of Range Recommended by US DOT ($13.3 million)	$14.6	37.2%	1.7
Fuel Cost	EIA Low-Case Scenario	$10.1	-5.2%	1.5
	EIA High-Case Scenario	$12.0	12.7%	1.6
Capital Cost Estimate	25% Reduction	$16.8	57.9%	2.2
Annual O&M Cost Estimate	25% Reduction	$12.7	19.1%	1.7

10. Supplementary Data Tables

This section breaks down all benefits associated with the five long-term outcome criteria (State of Good Repair, Economic Competiveness, Environmental Sustainability, and Safety) in annual form for the Transforming Dixie Highway. Supplementary data tables are also provided for some specific benefit categories.

10.1 Annual Estimates of Total Project Benefits and Costs (Millions of Dollars)

Calendar Year	Project Year	Total Benefits	State of Good Repair	Economic Competitiveness	Environmental Sustainability	Safety Benefits	Agency Fare Revenue	Total Costs Net of Agency Fare Revenue
2015	1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.2
2016	2	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$1.6
2017	3	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$12.1
2018	4	$2.0	$0.0	$1.3	$0.0	$0.7	$0.9	$10.1
2019	5	$1.9	$0.0	$1.3	$0.0	$0.6	$0.9	-$0.3
2020	6	$1.8	$0.0	$1.2	$0.0	$0.6	$0.8	-$0.3
2021	7	$1.7	$0.0	$1.1	$0.0	$0.6	$0.8	-$0.2
2022	8	$1.6	$0.0	$1.1	$0.0	$0.5	$0.7	-$0.2
2023	9	$1.5	$0.0	$1.0	$0.0	$0.5	$0.7	-$0.2
2024	10	$1.4	$0.0	$1.0	$0.0	$0.5	$0.6	-$0.2
2025	11	$1.4	$0.0	$0.9	$0.0	$0.4	$0.6	-$0.2
2026	12	$1.3	$0.0	$0.9	$0.0	$0.4	$0.5	-$0.2
2027	13	$1.2	$0.0	$0.8	$0.0	$0.4	$0.5	-$0.2
2028	14	$1.2	$0.0	$0.8	$0.0	$0.4	$0.5	-$0.1
2029	15	$1.1	$0.0	$0.7	$0.0	$0.4	$0.4	-$0.1
2030	16	$1.0	$0.0	$0.7	$0.0	$0.3	$0.4	-$0.1
2031	17	$1.0	$0.0	$0.7	$0.0	$0.3	$0.4	-$0.1
2032	18	$0.9	$0.0	$0.6	$0.0	$0.3	$0.4	-$0.1
2033	19	$0.9	$0.0	$0.6	$0.0	$0.3	$0.3	-$0.1
2034	20	$0.8	$0.0	$0.6	$0.0	$0.3	$0.3	-$0.1
2035	21	$0.8	$0.0	$0.5	$0.0	$0.3	$0.3	-$0.1
2036	22	$0.8	$0.0	$0.5	$0.0	$0.2	$0.3	-$0.1
2037	23	$0.7	$0.0	$0.5	$0.0	$0.2	$0.3	-$0.1
2038	24	$0.7	$0.0	$0.5	$0.0	$0.2	$0.2	-$0.1
2039	25	$0.6	$0.0	$0.4	$0.0	$0.2	$0.2	-$0.1
2040	26	$0.6	$0.0	$0.4	$0.0	$0.2	$0.2	-$0.1
2041	27	$0.6	$0.0	$0.4	$0.0	$0.2	$0.2	-$0.1
2042	28	$0.5	$0.0	$0.4	$0.0	$0.2	$0.2	-$0.1
2043	29	$0.5	$0.0	$0.3	$0.0	$0.2	$0.2	-$0.1
2044	30	$0.5	$0.0	$0.3	$0.0	$0.2	$0.2	-$0.1
2045	31	$0.5	$0.0	$0.3	$0.0	$0.1	$0.2	$0.0
2046	32	$0.4	$0.0	$0.3	$0.0	$0.1	$0.1	$0.0
2047	33	$0.4	$0.0	$0.3	$0.0	$0.1	$0.1	$0.0
2048	34	$0.4	$0.0	$0.3	$0.0	$0.1	$0.1	$0.0
2049	35	$0.3	$0.3	$0.0	$0.0	$0.0	$0.0	$0.0
Total		**$31.1**	**$0.3**	**$20.5**	**$0.3**	**$10.0**	**$12.4**	**$20.4**

10.2 Annual Demand Projections

Calendar Year	Project Year	BRT Ridership	Diverted from Auto	Diverted from Bus	Induced Demand
2015	1	0	0	0	0
2016	2	0	0	0	0
2017	3	0	0	0	0
2018	4	593,813	296,906	290,968	5,938
2019	5	594,229	297,114	291,172	5,942
2020	6	594,644	297,322	291,376	5,946
2021	7	595,061	297,530	291,580	5,951
2022	8	595,477	297,739	291,784	5,955
2023	9	595,894	297,947	291,988	5,959
2024	10	596,311	298,156	292,192	5,963
2025	11	596,729	298,364	292,397	5,967
2026	12	597,146	298,573	292,602	5,971
2027	13	597,564	298,782	292,807	5,976
2028	14	597,983	298,991	293,011	5,980
2029	15	598,401	299,201	293,217	5,984
2030	16	598,820	299,410	293,422	5,988
2031	17	599,239	299,620	293,627	5,992
2032	18	599,659	299,829	293,833	5,997
2033	19	600,079	300,039	294,038	6,001
2034	20	600,499	300,249	294,244	6,005
2035	21	600,919	300,459	294,450	6,009
2036	22	601,340	300,670	294,656	6,013
2037	23	601,761	300,880	294,863	6,018
2038	24	602,182	301,091	295,069	6,022
2039	25	602,603	301,302	295,276	6,026
2040	26	603,025	301,513	295,482	6,030
2041	27	603,447	301,724	295,689	6,034
2042	28	603,870	301,935	295,896	6,039
2043	29	604,292	302,146	296,103	6,043
2044	30	604,715	302,358	296,311	6,047
2045	31	605,139	302,569	296,518	6,051
2046	32	605,562	302,781	296,725	6,056
2047	33	605,986	302,993	296,933	6,060
2048	34	606,410	303,205	297,141	6,064
Total		**18,602,798**	**9,301,399**	**9,115,371**	**186,028**

10.3 State of Good Repair: Annual Benefit Estimates

Calendar Year	Project Year	Pavement Maintenance Cost Savings	Residual Value	Pavement Maintenance Cost Savings @ 7%	Residual Value @ 7%	Pavement Maintenance Cost Savings @ 3%	Residual Value @ 3%
2015	1	$0	$0	$0	$0	$0	$0
2016	2	$0	$0	$0	$0	$0	$0
2017	3	$0	$0	$0	$0	$0	$0
2018	4	$1,568	$0	$1,280	$0	$1,435	$0
2019	5	$1,569	$0	$1,197	$0	$1,394	$0
2020	6	$1,571	$0	$1,120	$0	$1,355	$0
2021	7	$1,572	$0	$1,048	$0	$1,317	$0
2022	8	$1,574	$0	$980	$0	$1,280	$0
2023	9	$1,575	$0	$917	$0	$1,244	$0
2024	10	$1,577	$0	$858	$0	$1,208	$0
2025	11	$1,578	$0	$802	$0	$1,174	$0
2026	12	$1,579	$0	$750	$0	$1,141	$0
2027	13	$1,581	$0	$702	$0	$1,109	$0
2028	14	$1,582	$0	$656	$0	$1,077	$0
2029	15	$1,583	$0	$614	$0	$1,047	$0
2030	16	$1,585	$0	$574	$0	$1,017	$0
2031	17	$1,586	$0	$537	$0	$988	$0
2032	18	$1,587	$0	$502	$0	$960	$0
2033	19	$1,588	$0	$470	$0	$933	$0
2034	20	$1,589	$0	$439	$0	$906	$0
2035	21	$1,590	$0	$411	$0	$880	$0
2036	22	$1,591	$0	$384	$0	$855	$0
2037	23	$1,592	$0	$359	$0	$831	$0
2038	24	$1,593	$0	$336	$0	$807	$0
2039	25	$1,594	$0	$314	$0	$784	$0
2040	26	$1,595	$0	$294	$0	$762	$0
2041	27	$1,596	$0	$275	$0	$740	$0
2042	28	$1,597	$0	$257	$0	$719	$0
2043	29	$1,598	$0	$240	$0	$698	$0
2044	30	$1,598	$0	$225	$0	$678	$0
2045	31	$1,599	$0	$210	$0	$659	$0
2046	32	$1,600	$0	$196	$0	$640	$0
2047	33	$1,600	$0	$184	$0	$621	$0
2048	34	$1,601	$0	$172	$0	$604	$0
2049	35	$0	$2,832,563	$0	$283,878	$0	$1,036,845
Total		**$49,189**	**$2,832,563**	**$17,305**	**$283,878**	**$29,864**	**$1,036,845**

10.4 Economic Competitiveness: Annual Benefit Estimates

Calendar Year	Project Year	Automobile	BRT	Automobile @ 7%	BRT @ 7%	Automobile @ 3%	BRT @ 3%
2015	1	$0	$0	$0	$0	$0	$0
2016	2	$0	$0	$0	$0	$0	$0
2017	3	$0	$0	$0	$0	$0	$0
2018	4	$537,872	$1,086,000	$439,064	$886,500	$492,229	$993,844
2019	5	$542,738	$1,102,197	$414,052	$840,861	$482,216	$979,288
2020	6	$547,799	$1,120,061	$390,573	$798,588	$472,536	$966,174
2021	7	$552,955	$1,138,940	$368,457	$758,924	$463,091	$953,844
2022	8	$557,493	$1,157,054	$347,178	$720,555	$453,293	$940,791
2023	9	$562,552	$1,176,318	$327,410	$684,628	$444,084	$928,596
2024	10	$567,606	$1,196,051	$308,740	$650,572	$435,023	$916,673
2025	11	$572,632	$1,216,135	$291,097	$618,222	$426,092	$904,919
2026	12	$577,098	$1,236,082	$274,175	$587,254	$416,908	$892,972
2027	13	$582,041	$1,256,837	$258,433	$558,051	$408,232	$881,520
2028	14	$586,970	$1,278,102	$243,572	$530,367	$399,698	$870,325
2029	15	$591,868	$1,299,793	$229,536	$504,082	$391,294	$859,316
2030	16	$596,134	$1,321,249	$216,067	$478,881	$382,636	$848,059
2031	17	$600,986	$1,344,018	$203,575	$455,266	$374,514	$837,548
2032	18	$605,887	$1,367,720	$191,808	$432,985	$366,572	$827,493
2033	19	$610,733	$1,391,810	$180,694	$411,786	$358,741	$817,542
2034	20	$614,790	$1,415,151	$169,995	$391,301	$350,606	$807,041
2035	21	$619,474	$1,439,911	$160,084	$372,100	$342,988	$797,244
2036	22	$624,071	$1,465,000	$150,721	$353,817	$335,469	$787,509
2037	23	$564,269	$1,489,695	$127,363	$336,244	$294,488	$777,461
2038	24	$632,407	$1,516,027	$133,404	$319,801	$320,435	$768,158
2039	25	$636,961	$1,543,405	$125,575	$304,277	$313,342	$759,253
2040	26	$641,210	$1,570,177	$118,142	$289,304	$306,246	$749,925
2041	27	$644,715	$1,597,055	$111,017	$275,006	$298,951	$740,546
2042	28	$648,867	$1,625,263	$104,422	$261,554	$292,113	$731,675
2043	29	$652,927	$1,654,005	$98,202	$248,766	$285,379	$722,927
2044	30	$578,839	$1,682,411	$81,363	$236,484	$245,628	$713,925
2045	31	$659,935	$1,712,233	$86,694	$224,931	$271,885	$705,417
2046	32	$663,672	$1,742,622	$81,481	$213,947	$265,460	$697,027
2047	33	$582,552	$1,772,645	$66,843	$203,395	$226,227	$688,384
2048	34	$669,925	$1,804,177	$71,839	$193,470	$252,579	$680,222
Total		**$18,627,978**	**$43,718,145**	**$6,371,577**	**$14,141,919**	**$11,168,955**	**$25,545,620**

10.5 Environmental Sustainability: Annual Benefit Estimates

Calendar Year	Project Year	Reduction in Air Emissions	Reduction in Air Emissions @ 7%	Reduction in Air Emissions @ 3%
2015	1	$0	$0	$0
2016	2	$0	$0	$0
2017	3	$0	$0	$0
2018	4	$28,438	$23,214	$26,025
2019	5	$28,566	$21,793	$25,380
2020	6	$27,935	$19,917	$24,097
2021	7	$26,888	$17,917	$22,518
2022	8	$26,832	$16,710	$21,817
2023	9	$26,342	$15,331	$20,795
2024	10	$25,884	$14,079	$19,838
2025	11	$25,376	$12,900	$18,882
2026	12	$24,877	$11,819	$17,972
2027	13	$24,779	$11,002	$17,380
2028	14	$24,283	$10,077	$16,536
2029	15	$23,796	$9,228	$15,732
2030	16	$23,384	$8,476	$15,009
2031	17	$22,633	$7,666	$14,104
2032	18	$22,572	$7,146	$13,657
2033	19	$22,172	$6,560	$13,024
2034	20	$21,775	$6,021	$12,418
2035	21	$21,669	$5,600	$11,997
2036	22	$21,560	$5,207	$11,589
2037	23	$21,744	$4,908	$11,348
2038	24	$21,624	$4,562	$10,957
2039	25	$21,502	$4,239	$10,577
2040	26	$21,632	$3,986	$10,331
2041	27	$22,040	$3,795	$10,220
2042	28	$22,162	$3,567	$9,977
2043	29	$22,282	$3,351	$9,739
2044	30	$22,398	$3,148	$9,504
2045	31	$22,647	$2,975	$9,330
2046	32	$23,169	$2,845	$9,267
2047	33	$23,416	$2,687	$9,093
2048	34	$23,661	$2,537	$8,921
Total		**$738,036**	**$273,261**	**$458,035**

10.6 Safety: Annual Benefit Estimates

Calendar Year	Project Year	Accident Cost Savings	Accident Cost Savings @ 7%	Accident Cost Savings @ 3%
2015	1	$0	$0	$0
2016	2	$0	$0	$0
2017	3	$0	$0	$0
2018	4	$800,921	$653,790	$732,956
2019	5	$811,181	$618,846	$720,724
2020	6	$821,557	$585,759	$708,682
2021	7	$832,050	$554,430	$696,829
2022	8	$842,661	$524,767	$685,160
2023	9	$853,390	$496,681	$673,674
2024	10	$864,240	$470,089	$662,368
2025	11	$875,209	$444,912	$651,238
2026	12	$886,301	$421,075	$640,283
2027	13	$897,515	$398,507	$629,499
2028	14	$908,852	$377,141	$618,884
2029	15	$920,314	$356,914	$608,436
2030	16	$931,901	$337,764	$598,152
2031	17	$943,615	$319,635	$588,030
2032	18	$955,455	$302,473	$578,066
2033	19	$967,424	$286,226	$568,260
2034	20	$979,522	$270,846	$558,608
2035	21	$991,749	$256,287	$549,107
2036	22	$1,004,107	$242,505	$539,757
2037	23	$1,016,597	$229,459	$530,554
2038	24	$1,029,219	$217,111	$521,497
2039	25	$1,041,975	$205,422	$512,583
2040	26	$1,054,865	$194,358	$503,809
2041	27	$1,067,889	$183,886	$495,175
2042	28	$1,081,050	$173,974	$486,677
2043	29	$1,094,347	$164,592	$478,314
2044	30	$1,107,782	$155,713	$470,083
2045	31	$1,121,355	$147,309	$461,984
2046	32	$1,135,068	$139,356	$454,012
2047	33	$1,148,920	$131,828	$446,168
2048	34	$1,162,912	$124,705	$438,448
Total		**$30,149,946**	**$9,986,360**	**$17,808,018**